IMP. INST. ENT
— LIBRARY —
E & A
13 APR 1946
U.S.A. 69

The PEA WEEVIL

AND METHODS FOR ITS CONTROL

FARMERS' BULLETIN NO. 1971

U. S. DEPARTMENT OF AGRICULTURE

In certain areas, particularly those marked by long and severe winters, such as the upper Snake River Valley of eastern Idaho and parts of Montana, or in areas characterized by exceptionally heavy and long-continued winter rains, as in the coastal area of northwestern Oregon, the pea weevil is generally rare or absent and of no economic importance. In general, any new area suitable for commercial production of peas can be evaluated as to potential damage from the pea weevil on the basis of infestations in home plantings or in small truck gardens in the area. If these plantings are usually injured by the weevil, it can be regarded as certain that large commercial acreages would ultimately be similarly affected, probably within 2 or 3 years at best.

Thus far the pea weevil has not established itself in the agricultural areas of Alaska, although several sections in the Territory are eminently suitable for producing edible peas of high quality.

CHARACTER OF INJURY

Pea weevils damage peas by the feeding of the larvae within the seeds. Generally but one larva develops in a single seed, but so many eggs may be laid that in extreme cases practically every pea may be infested. This is particularly true of certain areas in the Willamette Valley of Oregon, where infestations affecting from 70 to 90 percent of the crop have been observed and where they frequently average 30 to 70 percent, if control measures are not applied. In other sections, such as the Palouse area of eastern Washington and northern Idaho, the average is lower, although infestations ranging from 5 to 50 percent are not uncommon.

The injury done by a weevil larva is restricted to the seed, which it first enters shortly after hatching. In the course of its development the rapidly growing larva consumes a large part of the substance of the pea, thus destroying or greatly impairing the viability of the seed. The weevil-infested, or "wormy," peas are unfit for human consumption. In dry peas the feeding of the larvae not only destroys the viability of large numbers of the seeds, but also impairs their weight, food value, and palatability where they are grown and milled for stock feed.

PRINCIPAL SOURCES OF PEA WEEVIL INFESTATION

The principal sources of pea weevil infestation are (1) peas shattered in the field, (2) volunteer peas, (3) pea hay containing weevil-infested peas, and (4) weevil-infested seed in storage.

PEAS SHATTERED ON THE FIELD

Field shatter is the most important source of pea weevil infestation in seed-pea areas. From 7 to 50 percent of the peas in the fields are lost on the ground during harvest. From these peas the weevils emerge, seek hibernation quarters, overwinter until the following spring, and then attack the next year's crop (fig. 1).

FIGURE 1.—A typical bit of harvest loss due to shattering in a field of Alaska peas. In such shattered peas weevils survive to attack the next year's crop.

VOLUNTEER PEAS

Peas left on harvested fields often sprout during the winter and produce plants that bloom the following year in the winter wheat sown in those fields. These volunteer plants frequently become heavily infested with pea weevils and shatter out before the wheat is harvested. From the shattered peas the weevils emerge and are ready to infest the peafields the second spring.

PEA HAY

Peas grown for hay may liberate many pea weevils unless this hay is fed before such weevils can complete their development and escape. Hay cut while the pods are still nearly flat may contain seeds large enough to permit the pea weevil to complete its development. Such weevils are much smaller than those that feed on larger peas but are otherwise normal.

WEEVIL-INFESTED SEED

Seed containing living pea weevils is obviously a source of infestation because the weevil may escape from the place of storage. When the seed is planted before the weevils emerge, many of them survive and escape from the infested peas and the surrounding soil.

LIFE HISTORY AND HABITS

The adult pea weevil is a small, grayish or brownish-gray beetle about one-fifth of an inch long and marked with black and white spots (fig. 2, *A*).

The life cycle of the pea weevil is essentially a simple one, with a

single generation annually. The winter is passed in the adult stage. The weevils fly into the peafields at the end of the hibernation period, at a time which coincides rather closely with the blossoming period of the peas. The eggs are laid on living, green pods only. Unlike some of its relatives, such as the bean weevil (*Acanthoscelides obtectus* (Say)), the pea weevil is incapable of breeding continuously in the dried seed. Instead the larvae develop in the growing green

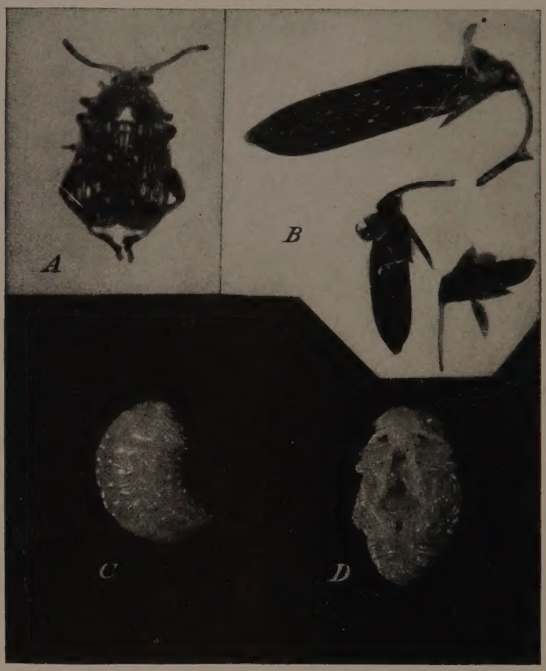

FIGURE 2.—The pea weevil: *A*, Adult; *B*, eggs on pea pods; *C*, larva; and *D*, pupa. All 4½ times natural size.

peas, completing their larval development some time after the normal crop has matured. They emerge from the infested seeds late in the summer and in the fall, and seek a protected spot in which to pass the winter, preparatory to repeating the cycle the following year.

The female weevil lays her eggs either singly or in pairs, one above the other, on the outside of the pea pod, attaching them to the pod by means of a transparent gluelike substance. When first deposited the egg (fig. 2, *B*), is orange, oval, slightly less than one-sixteenth of an inch long, and about half as broad. Six or seven days after the eggs are deposited, and about two days prior to hatching, a black spot appears at the end of each egg. This black spot is the head of the developing weevil grub, or larva. The time required for the egg to hatch depends on the temperature—it may hatch in 5 days in very warm weather, or may require several times as long in cool weather. In general, the average time required for hatching is about 8 or 9 days.

When the larva is ready to hatch, it bores through the thin shell

of the egg at the point of attachment, through the wall of the pea pod, and into one of the young peas within the pod cavity. Several larvae may enter one pea, but because of insufficient nourishment, only one is able to survive. A small, dark spot, or "sting," on the seed coat indicates the point of entrance. This "sting" can first be found in infested green peas (fig. 3). In some instances the newly hatched larva dies shortly after entering the pea, resulting in what is known as "pinhole" weevil infestation. The viability of the "stung" pea is not affected; nevertheless, in edible varieties such peas must be graded out and this constitutes a serious problem in certain areas and in certain seasons.

The newly hatched larva is white and about one-sixteenth of an inch long. It continues to feed within the growing pea and increases in size slowly, gradually consuming a large part of the interior of the pea, while the pea continues to grow. The larva attains its full

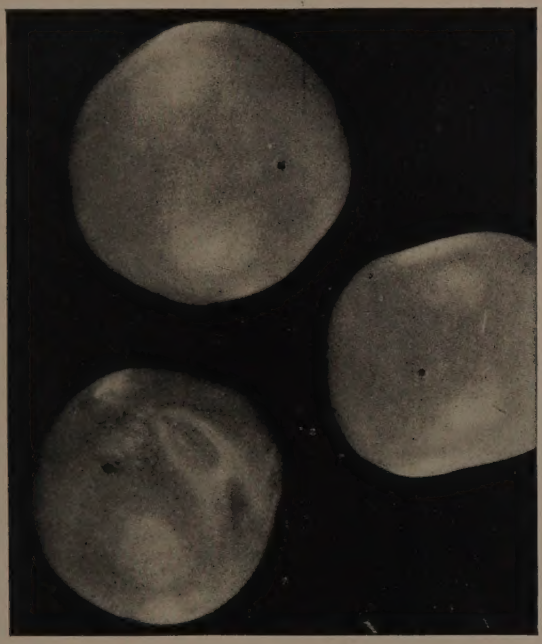

FIGURE 3.—Weevil-infested green peas. The small dark spots indicate places where the tiny larvae entered the peas.

growth at the end of 5 or 6 weeks. At this time its body usually fills a large part of the interior of the pea, which has developed to the ripened stage.

The full-grown larva is about one-fourth of an inch long and about half as wide. It is crescent-shaped, robust, slightly curled, and white or cream-colored (fig. 2, *C*). When the larva has reached its full size within the pea, it has eaten away the interior of the seed as far as the outer skin, leaving a thin circular cap, or "window," as a means of exit for the future adult.

Soon after it becomes full-grown the weevil larva transforms to the pupal, or resting, stage in the cavity formed by its feeding inside the pea. The pupa is about the same size as the adult weevil, and is cream-colored (fig. 2, *D*). Roughly oval in shape, the pupa shows on the delicate surface of its body the outlines of the legs, antennae, eyes, and mouth parts of the future adult. After 8 days to 2 or 3 weeks, depending on the temperature, the pupa transforms to an adult, thus completing the life cycle.

When the adult pea weevil is ready to emerge, it pushes out the circular "window" formed by the larva and crawls out of the pea (fig. 4). It may leave the pea soon after becoming an adult or, under certain storage conditions, it may stay all winter and emerge the following spring.

The entire developmental period of the pea weevil, from egg to adult, in the Northwestern States requires on an average about 2 months. In general, it is late in July or early in August before adults are developed and ready to emerge from peas seeded early in the spring.

Adult weevils emerge from ripe, unharvested, or shattered peas over a period of approximately 2 months, during the latter part of

FIGURE 4.—The adult weevils leave the peas and seek hibernation quarters shortly after completing development, unless the peas are stored in a cool, dry place.

the summer and the early part of the fall in the Northwestern States. In harvested peas the weevil, unless killed by fumigation or other treatment, may remain in hibernation within the container of the seed throughout the winter, escaping when the seed is removed from storage for planting or processing. Sometimes the adult weevil remains within the seed itself during this period. The pea weevil requires neither food nor water during the hibernation period, and weevils have been kept alive without either for 18 to 24 months. In

general, however, very few of the weevils confined in peas in storage from which escape is impossible (for example, when stored in tight bags) will survive longer than midsummer or early fall of the year following the harvest. A very few have survived a second winter in storage, but none have survived a third winter.

Except for the individuals that pass the winter in stored, nonfumigated seed, the adult pea weevil overwinters in any location affording protection from the weather. Such protection is found commonly in and about barns, in crevices in fence posts, in straw left on harvested fields, under the bark of trees, and in similar places. In the Palouse area of Washington and Idaho the rough bark of the ponderosa pine and the duff or dead leaves beneath these trees afford excellent hibernation quarters.

Exposure to temperatures below 0° F. will kill many overwintering weevils and thus reduce the infestation for the following year. In many instances, however, the weevils are so well protected in their hiding places that many survive when the temperature of the air is as low as —16°. Where snow cover affords additional protection, many pea weevils survive even much lower temperatures.

The pea weevils start coming out of hibernation quarters about the time the earliest peas begin to bloom. Some weevils may be found in the fields before any blossoms have appeared, but most of them fly in during the blooming period. Emergence from hibernation and flights into the peafields continue for 2 months or more, principally during May and June, on days when weather is favorable. Peak influxes occur on pleasant days when the temperature ranges from about 68° to 80° F. Other things being equal, the higher the temperature the larger is the flight. Weevils may fly at least 3 miles between overwintering quarters and peafields.

The weevils usually alight first near the edge of the first blossoming peafield they encounter; consequently the most heavily infested fields are those nearest favorable overwintering places, and the edges of the field, especially the edge nearest a favorable hibernation place, are almost always much more heavily infested than the interior. For instance, in the Palouse area the fields nearest ponderosa pine forests, which afford very favorable hibernating quarters, are usually the most heavily infested. When the time of blooming is not uniform, however, the weevils may concentrate on the early blossoming vines, regardless of their location in the field. In such areas as the Willamette Valley of Oregon, where the fields are relatively small and often located in densely populated areas, the parts of fields nearest houses, barns, and other outbuildings are usually most heavily infested.

The adult weevil does not feed to an important extent on its host plant, apparently being sustained during this stage by its accumulated fat reserves, supplemented by a diet composed largely of nectar and pollen. All direct injury done by this insect is consequently caused by the feeding of the immature, or larval, stages, the adults being important only as the parents of a new generation. The female, however, must feed on pollen in order to develop her eggs, and usually feeds on the pollen of the pea blossom. It is generally 4 or more days from the time she flies to the blossoming peas (fig. 5, *A*) before she begins to lay eggs (fig. 5, *B*). A female may lay several hun-

dred eggs during the season, and as many as 50 in 1 day, provided weather conditions are favorable.

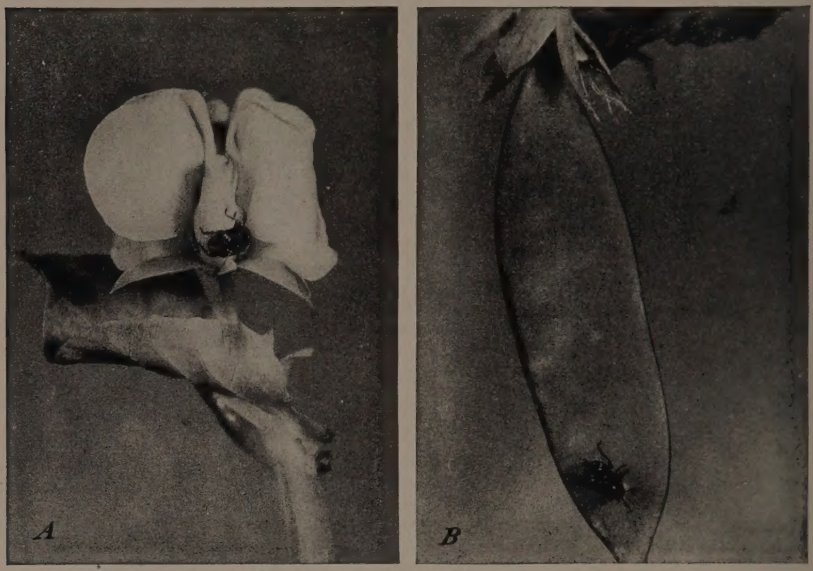

FIGURE 5.—*A*, After hibernation the weevils seek blossoming peas. They feed principally on the pollen of the pea flowers. *B*, As soon as the pods are formed, the females begin laying eggs on them.

NATURAL ENEMIES

Natural enemies, such as insect parasites or predators, do not seem to be important factors in holding pea weevil populations in check in the United States. In Europe parasites are present and in some places appear to be effective. From time to time attempts have been made to introduce certain of these parasitic species—*Triaspis thoracicus* (Curt.), in particular—into the pea weevil-infested areas of the United States, but thus far such attempts have failed. The role of predators, such as other insects and birds, has not been fully evaluated. Although many pea weevils are certainly destroyed by such enemies, there is no evidence that they are sufficiently effective to prevent pea weevil outbreaks.

CONTROLLING THE WEEVIL

The only effective method thus far sufficiently tested to justify recommendation for controlling field infestations of the pea weevil is dusting the infested parts of the peafield with a rotenone-containing mixture during the early bloom period and before the eggs are laid.

RECOMMENDED DUST MIXTURES

Dust mixtures employed for pea weevil control should contain not less than 0.75 percent of rotenone. Mixtures made from derris, cube, timbo, barbasco, or other rotenone-containing roots are equally effec-

tive when they contain an equivalent percentage of rotenone. The roots of these leguminous plants are imported from southern Asia and from South America. Although other toxic materials are present in the roots, rotenone is the yardstick with which the value of the roots and the mixtures containing them is usually measured. For convenience, therefore, the mixtures containing these materials will be referred to in this bulletin as rotenone-dust mixtures.

The finely powdered roots of the above-mentioned plants generally contain not less than about 4 percent of rotenone, plus the other associated active ingredients. The raw ground root must therefore be diluted to the recommended strength by the addition of inert diluents or carriers. The carriers most often used are talc and diatomaceous earth. Lime or any other alkaline substance should not be used as a carrier, because such materials may reduce the insecticidal value of the rotenone.

To keep the dust mixture at full strength up to the time of application, it should be stored in a tightly closed bag or other container that will not admit light.

Rotenone-containing dust mixtures kill the pea weevil principally by coming in contact with the weevil's body, although the weevil may swallow particles of the dust when cleaning its feet and antennae, and be poisoned thereby.

When used at the rate suggested for weevil control, dust mixtures containing rotenone are not poisonous to human beings or other warm-blooded animals. They do irritate the mucous membrane of the nose and throat, however, and a person continuously exposed to the dust mixture may find it desirable to wear a respirator.

The use of rotenone-containing dust mixtures has proved effective and economically worth while against the pea weevil on edible, seed, or Austrian field peas. The recommended procedures for their application to the three types of peas differ, however, because of varying commercial requirements.

APPLYING ROTENONE DUST MIXTURES

Peas Grown for Canning and Freezing

For peas grown for canning or freezing, a dust mixture containing not less than 0.75 percent of rotenone should be applied at the rate of not less than 20 pounds per acre, by means of a hooded dusting machine of the general type to be described later. Peas to be harvested while green should be dusted during the interval between the appearance of the first blossoms and the appearance of the first pods. The adult weevils are thus killed before they have an opportunity to lay their eggs on the pods. This period, from first blooms to first pods, ranges from 2 or 3 days in hot weather to more than a week in cool, cloudy weather.

After the dust has been applied, the action of sunlight rapidly reduces its effectiveness so that not many of the weevils that enter the field 24 hours later are killed. To protect the peas from reinfestation, therefore, it may be necessary to dust a second or even a third time, if more weevils fly into the field prior to harvesting. The period between successive applications will range from 2 or 3 days to more than a week, depending on the time when these flights take place.

In the heavily infested areas of the Willamette Valley in Oregon three applications during the season are sometimes required.

The longer the application is delayed, the more weevils are likely to fly into the field, and the more will be killed by the insecticide; but the consequences may be serious if dusting is delayed beyond the date when the first eggs of the season are laid. A delay of even 1 or 2 days after small pods have appeared may result in the peas becoming infested to such an extent as to render them unfit for canning or freezing. In general, it is much better to start dusting a little early.

Rain and wind sometimes interfere with the correct application of the dust. The use of dusting equipment may be impractical in muddy fields, and excessively windy weather may make dusting ineffective. Dusting should not be attempted when the wind velocity exceeds 12 miles per hour. Both rain and wind are frequently accompanied by cool weather, which causes the weevil to be relatively inactive. Most of the eggs are deposited at 70° F. or higher, and none below 65°.

Since power-dusting equipment cannot operate effectively on muddy fields, peas grown in irrigated areas should not be watered until after dusting has been completed. Under normal conditions and proper culture no damage to the peas should result from the delayed irrigation.

Dry Edible Peas Grown for Seed or Processing

The grower of green peas must attempt to eradicate the weevil completely from his fields. The control requirements for the grower of dry peas, on the other hand, are less rigid, because the processors can remove small percentages of weevil-infested peas in the course of cleaning. Furthermore, the relatively low per acre value of dry peas restricts the extent of dusting that is economically justified.

In general, only one application of the rotenone-dust mixture is recommended for dry edible peas. This application should be timed to avoid as far as possible a considerable amount of oviposition by the pea weevil. If the weather is unfavorable, dusting should be delayed until conditions are better. The temperature should be above 65° F., with indications that it will go higher, since weevils are usually inactive at temperatures below this level. It is extremely important, however, to remember that if dusting is delayed because of unsatisfactory weather the grower should be prepared to treat his peas immediately as soon as conditions become favorable. Otherwise, enough eggs may be laid to produce a serious infestation. A dust mixture containing 0.75 percent of rotenone should be applied at the rate of 15 to 20 pounds per acre, depending on the severity of the infestation. If a mixture containing 1 percent of rotenone is used, the rate of application may be reduced to 10 or 15 pounds per acre.

Austrian Winter Field Peas

Austrian Winter field peas should be dusted with a mixture containing 0.75 percent of rotenone, applied at a rate of not less than 20 pounds per acre, to control early and midseason infestations of the pea weevil. The peas should be harvested as early as possible and fumigated immediately in order to control late-season infestations by killing the small larvae before they have had time to prevent germination of the seed. Only one application is recommended, and this should be timed to follow as soon as possible the peak influx of pea

weevils into the fields from their hibernation quarters. In Oregon, which is currently the most important State in the production of Austrian peas, the growers are advised by the State extension service as to the proper time for dusting this crop.

Control of the pea weevil in Austrian Winter field peas differs essentially from that in other pea varieties, because they are not used for food and the sole requirement for a commercial product is seed that will stand a satisfactory germination test (usually 90 percent or higher). The presence of infested peas in the final product is unimportant, provided the weevil larvae have been killed by fumigation before they become large enough to impair germination. On the other hand, the viability of almost all the early infested seed peas is destroyed before harvest, and in order to obtain a marketable product such seeds must be removed in the course of cleaning. Unless early infestations are controlled, losses in yield may be very high. In severe infestations ordinary methods of cleaning are inadequate to separate the sound from the weevil-infested seed.

DETERMINING WHEN AND WHERE TO DUST

Since the pea weevil populations are generally not distributed uniformly throughout a field, but are most often concentrated in a narrow zone around the edges, especially the edges close to favorable hibernation quarters, it is often unnecessary to apply the rotenone-dust mixture to an entire field, particularly if it is fairly large. The parts of the field that require dusting can be determined only on the basis of actual weevil-population surveys made by the grower or control operator. Such surveys are most quickly and accurately accomplished by the use of an insect-collecting net. Figure 6 shows the insect net

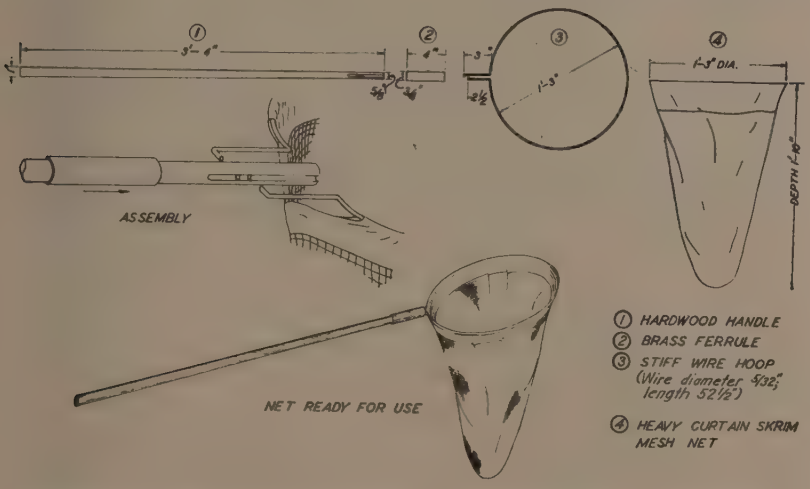
ASSEMBLY
NET READY FOR USE
1 HARDWOOD HANDLE
2 BRASS FERRULE
3 STIFF WIRE HOOP (Wire diameter 9/32"; length 52½")
4 HEAVY CURTAIN SKRIM MESH NET

FIGURE 6.—Insect-collecting net used for the determination of pea weevil populations.

commonly used for this purpose and how it is made. In heavily infested areas, particularly where peas are grown for canning and

freezing, it is often necessary to dust the entire acreage of small fields, that is, those that do not exceed 8 to 10 acres.

The method of determining the weevil infestation may be outlined as follows:

Sweep the field soon after the first blossoms have appeared and before dusts have been applied. Go into the field in several places on each of the four sides or, if the field is irregular in shape, sweep at intervals around it. Each stroke across the upper part of the vines is considered a sweep. Hold the net at such an angle that weevils knocked off the vines will fall into it. Take a step or two between each sweep. Figure 7 shows the proper way to sweep. Make two or more 25-sweep collections at each place swept and count the weevils in each collection. Work toward the center of the field until no more weevils are found. In a field of seed peas sweep toward the center of the field until the weevil population drops below the number for which it is considered profitable to dust, as discussed in the following section of this bulletin. On a rough map of the field mark the locations where the weevils were collected. To keep track of these locations it is helpful to step off the distance from the edge and sweep at 100-foot intervals. For instance, if a number of weevils are found 200 feet from the edge of the field, walk another 100 feet and sweep again. If this method is followed, it is easy to mark the distance on the map.

Pay particular attention to the places most likely to be severely infested. Examine the edge nearest extensive timbered or brushy areas, ravines, and gullies running into the field; the vicinity of sheds or trees; and areas where the first peas blossomed, if the bloom is spotted. Check on the effect of the dusting operations in a similar manner 18 to 24 hours after dusting. If many weevils are found, it may be necessary to dust again within 3 or 4 days. It should be emphasized again that the green-pea field must be kept practically weevil-free, but in seed peas a light infestation is not so important. For this reason a more thorough check is needed on the green-pea field, both before and after dusting.

The question is frequently asked, How many adult pea weevils does it take to produce an infestation of 5, 10, or 15 percent in the harvested peas? An infestation resulting from a given number, as determined by sweeping with a collecting net, varies greatly in different fields. Weather has an important effect on both the yield of the peas and the activity of the weevils. The same number of weevils, as determined by sweeping, produce a greater infestation in the later fields than in the early ones. A population of 5 weevils in 50 sweeps often causes an infestation at the canning stage of about 1 to 2 percent in the early Alaska, Surprise, and Wisconsin Early Sweet peas, whereas the same population in the later varieties (Perfection and others), which bloom after June 15, results in an infestation of 10 to 25 percent at the canning stage. An infestation in the dry seeds resulting from 1 weevil in 25 sweeps averages from 3 to 8 percent in the harvested peas. In undusted midseason and late peas in eastern Washington, 1 weevil in 500 sweeps produces an infestation that generally ranges from 0.2 to 0.8 percent at the time of vining; 2 weevils in 500 sweeps produces an infestation that generally ranges from 0.6 to 1.1 percent. The higher percentages of infestation in late peas is due

partly to higher temperatures, which are more favorable to egg deposition, and partly to the ranker, leafier type of growth, which makes them more difficult to sweep, so that probably a smaller fraction of the weevils are picked up by the net.

FIGURE 7.—Sweeping with an insect-collecting net to determine pea weevil populations.

By applying this information a farmer or pea processor can determine whether dusting would be economical. For example, a producer of dry peas, knowing that the collection of 1 weevil per 25 sweeps would cause a loss of 3 to 8 percent of the harvested peas over the infested area, and also knowing the value of the crop and the cost of application, would be able to determine just how much of his crop could be dusted with profit.

SUPERVISION OF LARGE-SCALE DUSTING OPERATIONS

Some processors and some canning-pea growers who operate on large acreages have found it profitable to employ trained entomologists to supervise weevil-control work. These men are responsible for the

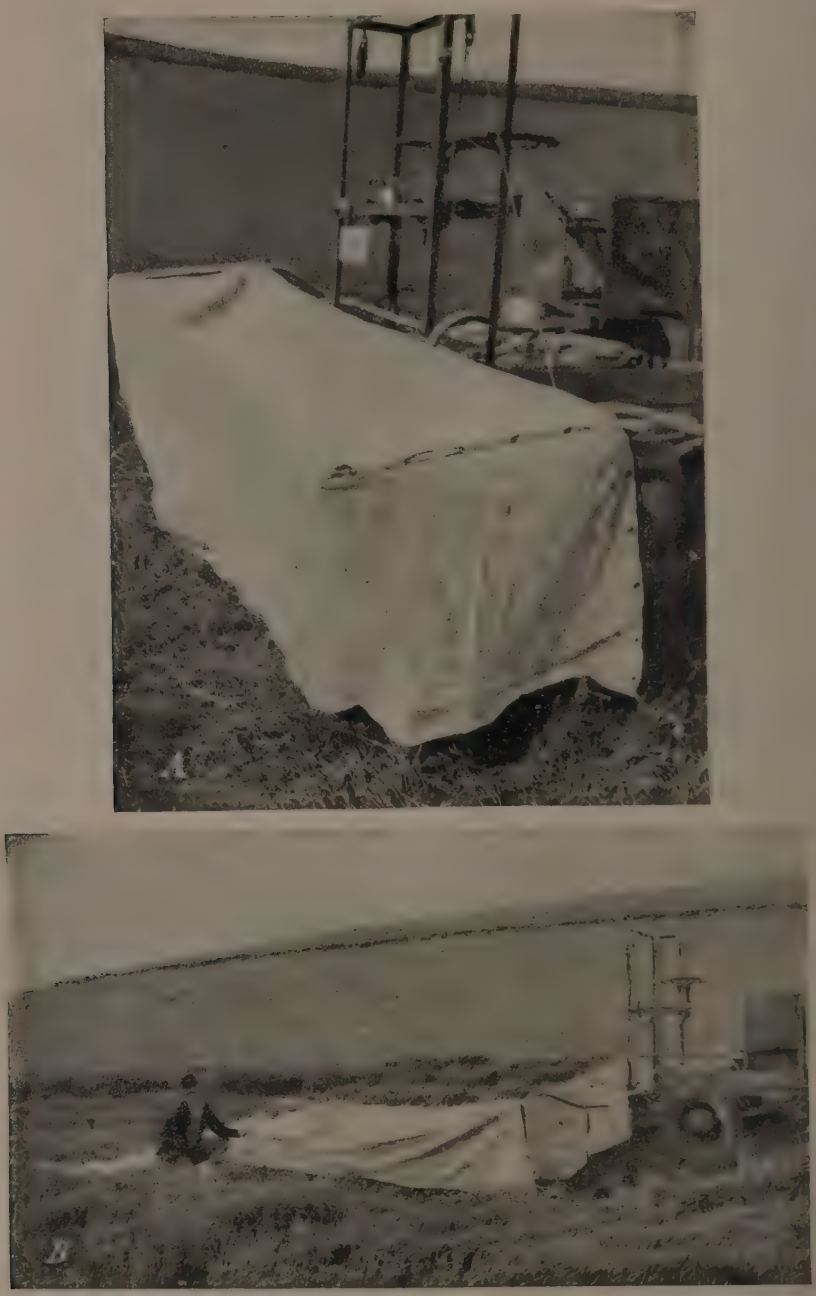

FIGURE 8.—Canvas hoods confine the dust mixture for a short period and thereby increase the efficiency of the duster. *A*, Box type; *B*, trailer type.

proper timing of dust applications under the local conditions encountered and for determining the field areas to be treated. They must also see that dusting is repeated when and if necessary and that in general only clean peas, satisfactory for processing, are harvested. It is important that such men be well trained and fully familiar with the pea weevil problem. If this practice were more generally followed in important or concentrated pea-producing areas, greater profits would probably result.

DUSTING EQUIPMENT

A number of satisfactory dusters have been developed for use in pea weevil control. With the aid of a light canvas hood on a frame built out over the dust outlets, it is possible to make satisfactory application in winds having velocities up to 12 miles per hour (fig. 8). The dust mixture swirls in a heavy fog within this hood before settling on the vines, so that a very even distribution is obtained (fig. 9). Most hoods are 3 or 4 feet high and project from 12 to 25 feet on each side of the machine.

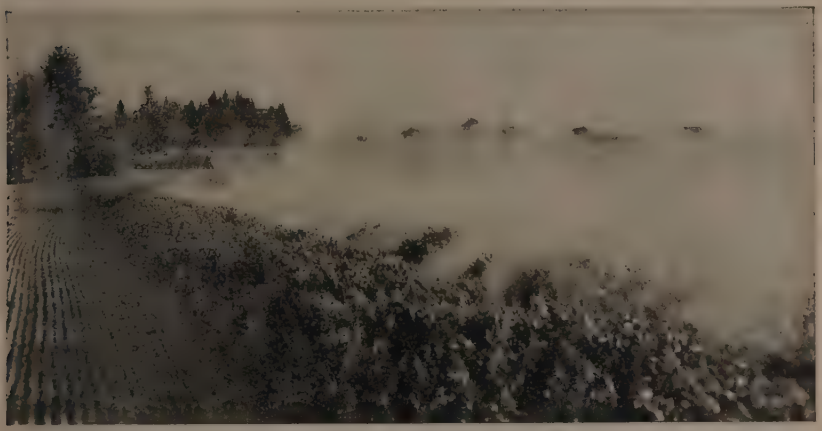

FIGURE 9.—A typical dust fog following the application of a rotenone dust mixture with a duster equipped with a hood.

The top of the hood is supported by a stout frame, which is jointed to the sides of the vehicle so that it can be folded when the duster is moved to or from the field. The bottom of the hood is weighted with some heavy material, such as rope, hose, or chains, to prevent whipping by the wind.

The boom is sometimes enclosed by a short apron, which hangs down vertically in front of the dust outlets and affords additional protection from the wind while the mixture is being applied.

No two dusting machines have been built entirely alike (fig. 10), and the hood, together with the boom, has been folded in various ways. Constructing the hood so that it can be easily and quickly folded speeds operations and enables better timing of applications. Some hoods can be folded and swung either to the front or to the rear of the machine (fig. 11, *A*). Others can be telescoped to reduce the

length when the machine travels to or from the fields. On others the frame is jointed on each side of the machine so that it can be folded over before being raised to a vertical position (fig. 11, *B*). If the duster is efficiently constructed, it should not take more than 4 or 5 minutes to fold the hood and make all preparations to move to the next field.

FIGURE 10.—*A*, Small horse-drawn machine duster covering a swath 20 feet wide; *B*, large tractor-drawn and powered duster covering a swath 60 feet wide.

There are two kinds of discharge outlets—nozzles and perforated booms. Both have proved satisfactory. On nozzle-type dusters the number and arrangement of the discharge nozzles can be varied. In some places as few as three nozzles have proved satisfactory when box-type hoods were employed. Usually, however, five or more

FIGURE 11.—*A*, Duster constructed so that the hood and boom assembly can be folded and swung to the rear of the dusting unit; *B*, duster built so that the hoods can be folded and raised to a vertical position.

nozzles are used, arranged, after experimentation, to ensure an even covering of the dust mixture. As an example of the perforated boom, a duster was fitted with two 20-foot booms, one on each side of the machine. These booms were prepared by welding an 8-foot section of 3-inch boiler pipe to a 6-foot section of 2¾-inch pipe and then welding to these a 6-foot section of 2¼-inch pipe (fig. 12, *B*). Holes, ⅜ inch in diameter and 4 inches apart, were drilled along the bottom. A feed made of flexible tubing connected the larger end of the pipe with the

dust blower. The end of the boom was fitted with a removable pipe cap, so that the pipe might be cleaned, should it become clogged.

Most of the dusters cover a swath from 30 to 50 feet wide. They

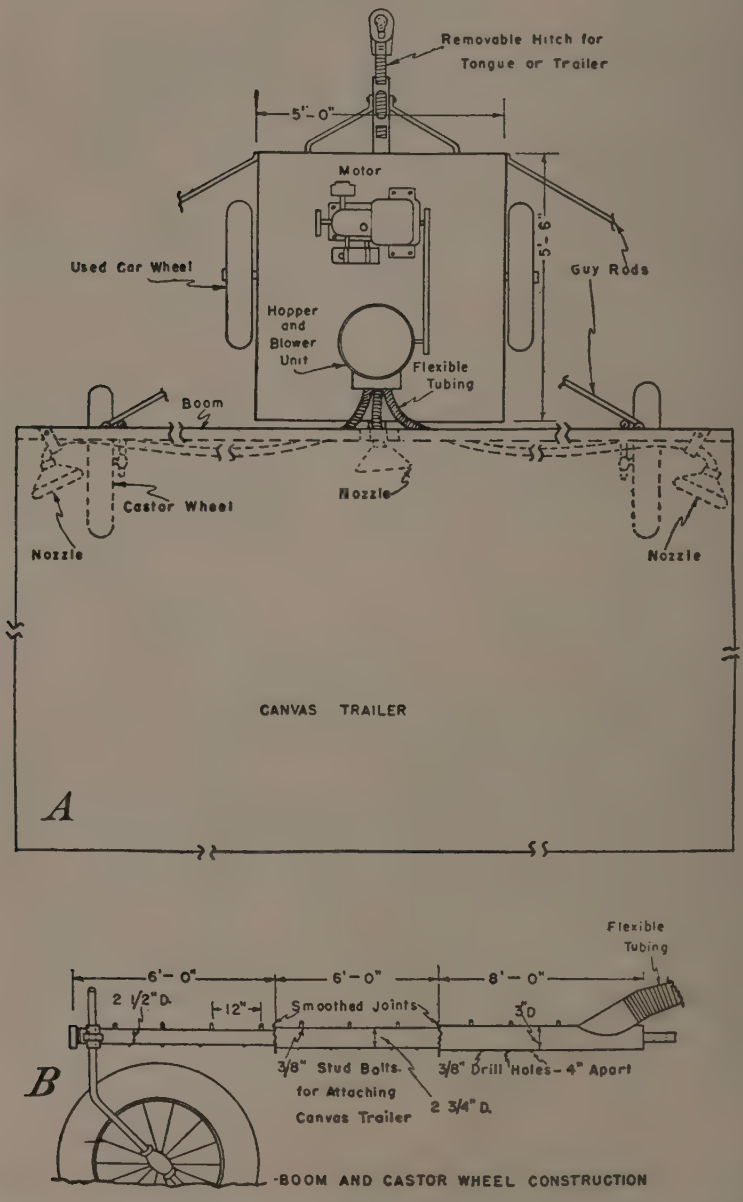

FIGURE 12.—*A*, Diagram of duster, showing nozzle-type boom; *B*, detailed section of perforated-type boom.

FIGURE 13.—*A*, Caster wheel at end of framework of the duster hood. Such wheels keep the hood at a constant distance from the ground and eliminate the use of a windlass. *B*, Duster with hood of the trailer type. This type of hood affords protection from wind during the dusting operation. The unit is mounted directly on the tractor, and the booms are supported by caster wheels.

have been mounted on trucks or tractors or on truck- or horse-drawn trailers.

Where fields are several miles apart or where they are so steep that

the duster must be pulled by a crawler-type tractor, time is saved by loading the tractor and the dust mixture onto a truck and hauling the duster behind the truck to the next field.

Most dusters are operated by two men, one driving the machine and the other regulating the distance of the hood from the ground by means of a simple windlass arrangement. One windlass for each side of the hood enables the operator to obtain the best adjustment on sloping land. The windlass should be large enough in diameter to enable the hood to be raised without a great deal of turning of the windlass wheel.

On some machines, however, the windlass wheel has been eliminated by the use of a caster wheel placed near the end of the supporting boom (figs. 12 and 13). This wheel keeps the trailer hood at a uniform height above the peas, no matter what kind of ground surface is being dusted. The use of caster wheels also eliminates the construction of a costly and heavy supporting framework for the duster boom. Little damage is done to the vines by these wheels because they support little weight.

Accurate mileage can be determined with a speedometer connected with a bicycle or automobile wheel riding on the duster wheel; or, if the duster is mounted directly on a tractor, riding on the treads of the tractor. Such a record makes it possible to determine how many pounds of dust mixture are being applied per acre, so that the grower may know whether he is wasting dust or not applying enough.

Dusting machines of the type used in pea weevil control can be purchased from local implement dealers. Most shops that specialize in the repair and maintenance of farm machinery can mount and equip machines in the manner described in this bulletin. Made-to-order canvas hoods can be supplied by dealers in dusting machines.

Damage Caused by the Dusting Equipment

The damage to the peas that results from running the dusting equipment over the vines varies with the slope of the ground, the weight and width of the duster, the width of the duster tracks, and other factors. For instance, a 30-foot duster mounted on a truck or a duster pulled by a caterpillar tractor with 8-inch cleats frequently causes enough damage to reduce the yield between 3 and 4 percent in the part of the field that is dusted. Horse-drawn dusters usually do less damage per trip than dusters pulled by machine equipment, but since they usually dust a narrow swath and have to make more trips across the field, the damage done in the end is approximately the same. Duster damage can be materially reduced either by increasing the width of the duster, which means decreasing the number of trips across the area to be dusted, or by decreasing the width of the tracks made by the dusting equipment. Light dusting equipment, which reduces damage, is of especial importance in small fields.

COST OF APPLYING ROTENONE-DUST MIXTURES

The cost of dusting for pea weevil control varies from year to year with the cost of labor and materials, the size of the field treated, the number of applications required, the type of peas grown, and the general severity of the infestation. The cost of recommended dust

mixtures containing 0.75 percent of rotenone has ranged from 5 to 12 or 13 cents per pound, depending on the season, the locality, and the brand of dust mixture used. In general it is more economical to dust large fields than small ones, owing to the smaller percentage of the total area requiring dusting and to the feasibility of using larger and more efficient dusting units. Where custom dusting has been utilized, the costs have ranged from 40 cents to $1 per acre for the field area actually covered. In general, under prewar conditions, the cost of actual material and labor ranged from $1.70 to $2.50 per acre per application.

BORDER TRAP STRIPS

In some areas a strip of early blooming peas is sown around the margin of a large field to serve as a trap crop. This strip is usually one drill-strip wide and is so planted that it blooms a week or 10 days ahead of the main field. It attracts large numbers of pea weevils, causing them to concentrate where they may be destroyed. Weevils concentrated in the borders must be eliminated by the application of dust mixtures containing rotenone at the same rate and with the same equipment recommended for regular field control. The dust should be applied to the border trap strip before the buds in the main field show any white coloration.

Because pea weevils sometimes fly into the blossoming field after the weevils in the border trap strip have been destroyed, the grower often has to dust this strip a second time and also has to dust a portion of the main field. Nevertheless, the quantity of dust used in control and the size of the area treated are usually less than if border trap strips had not been used. In seed-pea areas, where the grower is merely attempting to reduce this population as much as possible with a minimum of dusting, the use of a border trap strip enables him to kill a great many weevils with a relatively small quantity of the dust. In general, the use of border trap strips is not recommended except for fields of 75 to 100 acres or more.

If the border trap strip is to be helpful rather than harmful, certain precautions should be observed. It is important that the pea weevils in these strips be destroyed by dusting before the main field blooms; otherwise some weevils will fly over into the main field. The peas in these borders are often heavily infested and, if the crop is grown for canning, should be plowed under or otherwise destroyed as soon as possible after the main field blooms. Unless the plowing is carefully done, some pea vines are likely to catch onto the plowshares and be left in small bunches scattered along the border. If these peas are infested, the chances are that the pea weevils will develop within them and become a menace to the next year's crop. Deep plowing, with the use of jointers, usually buries the peas effectively. Going over the border with a packer helps to prevent any pea weevils that may develop in the buried peas from forcing their way to the surface of the soil. In some cases, where the border dusting has been effectively done, the peas in the border strip may be harvested. *If peas are being grown on contract, border trap strips should not be planted without the consent of the firm granting the contract.*

SANITATION AND RELATED PRACTICES

To reduce pea weevil populations from year to year, certain cultural and sanitation practices should be adopted, as follows:

1. Plant weevil-free seed. Large numbers of pea weevils are able to escape from weevily seed and infest the growing crop.

2. Use good seed stock. Any practice that will eliminate rogue pea plants will aid in keeping down the pea weevil infestation and the cost of control. Good seed planted in a good seedbed is an important factor. A few early blossoms in a peafield may attract weevils out into the field several days before the field as a whole begins to bloom. To destroy these weevils before they lay eggs, it may be necessary to dust entire fields when few blooms are present. Because this application must be made before the true variety blooms and usually before the weevils are out of hibernation, a second dusting may be required after the field comes well into bloom and more weevils have flown in, whereas only one dusting would have been needed had all the peas bloomed at the same time.

3. Do not grow seed peas in green-pea districts. The pea weevil population in areas devoted primarily to growing green peas for canning, freezing, or the green-pod market can be greatly reduced if no peas are allowed to ripen in such districts. It is possible, however, with the application of recommended control measures, to grow both seed and green peas in such areas. In eastern Washington the harvest loss is greater and the weevils are further developed at harvesttime in the seed-pea fields than in the green-pea fields; consequently a much larger percentage of weevils survive in the shattered seed peas. On fields harvested for seed in Columbia and Walla Walla Counties, Wash., the shatter of pea seed of the same varieties was found to be 6 to 7 times as great as on fields harvested for the cannery. In one study more than 20 times as many pea weevils developed from shattered seed peas as from cannery peas collected from areas of equal size in adjacent fields.

The following is an example of the effect on the abundance of pea weevils of an undusted field left for seed in a canning-pea area. One farmer raised 9 acres of peas for hay, so planted that they blossomed just ahead of the canning peas in the area and became host to most of the weevils in the vicinity. The peas were cut for hay, raked, and stored in the barn. On the basis of collections made at random on the plant residues left on the surface of the harvested field, it was estimated that approximately one quarter of a million pea weevils developed and emerged on these residues. This total probably exceeded the total number that reached the mature stage in approximately 2,000 acres of canning peas surrounding this field.

4. Harvest seed peas as soon as they ripen. This is important from the standpoints of both yield and weevil damage. Sometimes peas are cut while still green and are left in windrows to dry before being harvested. This practice enables the farmer to thresh the peas earlier, but does not materially reduce field shatter.

5. Fumigate Austrian Winter field peas as soon as they are harvested. Harvest them as soon as they ripen, and fumigate them immediately; otherwise the feeding of the weevil larvae within the peas will steadily decrease their weight and lower the percentage that will germinate. Effective fumigants include carbon disulfide, carbon tetrachloride, a mixture of ethylene oxide and carbon dioxide, chloropicrin, and hydrocyanic acid gas. Instructions for the use of these fumigants are given in Farmers' Bulletin No. 1275, Weevils in Beans and Peas.

6. Store dry edible peas until the weevil larvae mature, and then fumigate them. They should be stored in tight bags to prevent the escape of emerging adults and under conditions favorable for rapid weevil development. When the larvae have completed their development the peas should be fumigated or otherwise treated to kill the living weevils present, and thus prevent their emergence and the subsequent infestation of the next year's crop.

7. Do not allow weevils to complete development in peas left in the field. Deep plowing, using jointers, immediately after harvest destroys most of the weevils in peas left on the field. Unless they are properly handled, weevil-infested peas intended for canning, but left for seed, breed more weevils for succeeding crops. Such peas should be harvested as soon as they are ripe, to prevent the escape of weevils. Some growers and canners prefer to plow under such peas, or to cut them green and use them as hay or ensilage. If the peas

are cut for hay, it should be used before spring to prevent weevils from surviving. Practically all the weevils in the peas used for ensilage are destroyed in the curing process.

Peas grown as a green-manure crop should be plowed under shortly after blossoming and before any pods have started to fill.

After canning peas are harvested the pasturing of livestock is an effective method of destroying weevil-infested peas left in the field, but this practice is not very effective after dry peas have been harvested.

Burning over harvested fields kills the pea weevils in shattered peas left on the field. *This practice is not recommended, however, because of the injurious effects on the fertility of the soil.*

Whenever fields are some distance from favorable overwintering places, such as timber or brush, it may be advantageous to clean up abandoned orchards,

FIGURE 14.—Dusting home-garden peas for weevil control.

old fences, and farm buildings or any other places in which the weevils pass the winter near the peafield.

CONTROL OF THE PEA WEAVIL IN HOME GARDENS

Pea weevils in farm and home gardens must also be eliminated if the gardener is to produce sound peas. The presence of the pest can be determined by examining the pea flowers and terminal buds. If any weevils are found in a 5-minute examination, the peas should be dusted with a mixture containing 0.75 percent of rotenone. The dust should be applied with a hand duster, and the entire plant should be covered completely with a thin layer of the insecticide (fig. 14). One-fourth of a pound to each 150 linear feet of row should be sufficient. Control can also be accomplished by dusting with the same mixture at intervals of 4 to 5 days from the time the peas start blossoming until the green-pea harvest is over.

WHERE INSECTICIDES MAY BE PURCHASED

Information regarding the purchase of the insecticide materials mentioned in this bulletin may be obtained through local dealers in agricultural supplies, seedsmen, general stores, and department stores or through county agricultural agents, State agricultural experiment stations, State agricultural colleges, or State departments of agriculture.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1945—646847